J. New York Entomol. Soc. 101(4):581–585, 1993

Life in Amber.—G. O. Poinar, Jr. 1992. Stanford University Press. $55.

> . . . for I do not allow that there is any river, to which the barbarians give the name of Eridanus, emptying itself into the northern sea, whence (as the tale goes) amber is procured . . . I have never been able to get an assurance from an eye-witness that there is any sea on the further side of Europe. Nevertheless tin and amber do certainly come to us from the ends of the earth.
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> Herodotus, *The History*, III, 115.

One of the few and probably the most promising areas where systematic entomology interfaces with the fossil record is amber studies. To a systematic entomologist, the fossil record of terrestrial arthropods consists of two fundamental types of deposits: compression deposits formed by the settling out of various fine-grained, water-lain sediments, and amber, the lithified result of wood resins produced by gymnosperm and angiosperm trees. Unlike amber, compression deposits form the stratigraphic context that provides our understanding of the major patterns of terrestrial arthropod evolution during the past 400 million years of deep geologic time. These include the diversification of various paleopterous and orthopteroid insect clades of the Paleozoic Entomofauna during the Paleozoic Era, and the appearance and frenzied radiation of hemimetabolous and holometabolous clades of the Modern Entomofauna during the late Paleozoic Era and the first half of the Mesozoic Era. Amber, by contrast, divulges the relatively recent patterns of the Modern Entomofauna during the past 140 million years, corresponding to the flowering of angiosperms during the Cretaceous Period of the Mesozoic and their continued diversification during all of the Cenozoic Era. It is intriguing to note that, unlike virtually any other major terrestrial clade (e.g., vertebrates or vascular plants), the Modern Entomofauna largely would be recognizable to an entomology student time-travelling back to a Cretaceous forest and keying insects to the family level. In this latter context, G. O. Poinar's book, *Life in Amber,* provides a welcome summary of current research and a comprehensive taxonomic compendium of amber inclusions (principally insects and arachnids) for all major amber deposits that have come to us, as Herodotus put it, from the ends of the earth.

In his preface, Poinar states that the goal of *Life in Amber* is a synthesis ". . . to include plant and animal remains as well as information on the sources of fossiliferous amber deposits in the world, their location, their history, and, especially, their geological ages" (pp. vii–viii). This far-ranging goal is admirably realized for most discriminating readers in the 288 pages of written text. The first chapter is a fifteen page précis devoted to a cultural appreciation of amber in mythology, the classical world and more recent European history, followed by a practicum on differentiating recent resins (known as copal) from more ancient ambers, and it concludes by a succinct discussion of diagenetic processes involved in the formation of amber. In the second chapter, we are presented with more focused discussions, largely from the author's personal experience, of Cenozoic ambers from Chiapas, Mexico and the Dominican Republic, as well as a more extensive exposition on Baltic amber. More abbreviated sections are devoted to other Cenozoic amber deposits, principally because of their inaccessibility and less productive yields of inclusions—namely Chinese (Fu Shun), Romanian, Burmese and Sicilian ambers. The last section on Cretaceous ambers provides information on Canadian, Alaskan, Mideastern (principally Lebanese), Siberian, Atlantic Coastal Plain (especially New Jersey), and other lesser known amber deposits. Chapter 3 consists of a list of museums that are amber repositories, and a brief note of what constitutes value in amber. (It is no surprise that, unfortunately, what is of scientific value for the biologist also can command outrageous prices in Manhattan jewelry stores!) By far the overwhelming bulk of the text (177 pages, or 60 percent) is devoted to a systematic compendium, generally at the family level, of all major taxa that have been described or are known from amber. The taxonomic spectrum ranges from bacteria to mammals, although, fortunately for entomologists, 82 percent of the chapter is devoted to terrestrial arthropods, mostly insects and arachnids. Although this chapter adequately provides basic data for the specialist and nonspecialist interested in a synoptic overview of occurrences of taxonomic groups in amber, cognoscenti may be misled by some omissions and errors (more on this later). Chapter 5 comprises 10 pages of what is known of symbiotic relationships among amber taxa, addressing evidence for commensalism, mutualism, and parasitism and disease. For me, this was the most fascinating section of the book, and it reflects the research of Poinar and his collaborators. The types of interorganismic interactions in amber that are rarely obtainable in compression deposits include mite and pseudoscorpion phoresy on insects, ectoparasitism of an apid bee by a meloid tringulin larva, and nematode endoparasitism of flies. The concluding chapter presents topical and timely digressions of the principal implications of amber for evolutionary biology, other than the sheer documentation of alpha diversity through time.

Given the price of many technical books in the life sciences, a 350 page book with eight color plates for $55.00 seems reasonable. The organization of the book is logical and the format is pleasing. The 144 black-and-white photographs reproduced on text pages, some of which have been reproduced elsewhere, range from the stunning to the unidentifiable; the average quality is quite high, given the translucent nature of amber. Squeakers include the listrophorid fur mite of p. 227, which resembles an ink-splatter spot, and the photo of the Brodzinskys on p. 46, which is somewhat less than flattering. (The Brodzinskys, incidentally, have assisted entomologists immeasurably in obtaining access to important amber specimens.) The 37 color photographs of the plates are superb and reveal considerable detail, although some could have been enlarged and still be accommodated within the page margins. Although the figures with graphics are stylistically uneven, they adequately document what is referred to in the text.

My principle qualm with the book are isolated, misleading statements in Chapter 4 that fall into three categories. They are: (1) erroneous accounts stating that the earliest known occurrences of many insect families occur in amber, when in fact reliably identified representatives of these families occur in older compression deposits; (2) outdated usage of higher-level designations of taxonomic rank; and (3) general proofreading and typographical errors. With regard to the earliest occurrences of insect families that predate amber deposits, examples include the earliest known gryllotalpid occuring during the Aptian Stage of the early Cretaceous of Brazil (Martins-Neto et al., 1991), rather than in Cenozoic Mexican amber (p. 102), the earliest identified bibionid is not from upper Cretaceous Canadian amber (p. 165) but from the mid-Cretaceous of Botswana (Rayner, 1987), and the earliest known flea is a specimen from the early Cretaceous Aptian Stage of Australia (Jell and Duncan, 1986), and not from Baltic amber (p. 189). There are other examples. Lastly, the earliest known feather is not from lower Cretaceous Lebanese amber (p. 239), but can be found individually and on the wings of *Archaeopteryx,* from the upper Jurassic Solnhofen limestone (Meyer, 1861; Feduccia, 1980), the protestations of Hoyle and Wickramasinghe notwithstanding. Much of the inaccuracy regarding earliest insect occurrences arises from a flurry of systematic activity within the last decade from seven, well-worked, mostly lower Cretaceous compression deposits from Australia, Botswana, Brazil, China, Mongolia and Russia, whose results are published in journals and edited volumes that are relatively inaccessible (Grimaldi and Maisey, 1990). Unfortunately, Carpenter's new compendium (1992) has a literature cutoff date of 1983, and virtually all of these discoveries are not documented in his compendium.

As to the inappropriate use of higher level taxa, it would have been useful to standardize taxonomic terminology by following the scheme of a universally used reference, such as the second edition of *The Insects of Australia* (1991). Examples include the anachronistic use of the term, Orthoptera (p. 99), to include at least six, currently recognized orthopteroid orders; and use of Thysanura to include Archaeognatha plus Zygentoma (p. 96), which contravenes recent progress in delineating fundamental distinctions between these two clades. General errors of fact include the claim that ". . . there have been two great coal-forming periods, the first lasting from the Carboniferous to the Permian, some 120 million years in duration, and the second in the Tertiary Period, . . ." (p. 14), when, in fact, coal deposits of the Cretaceous are as volumetrically impressive as those of the Carboniferous (Averett, 1975; Cross and Phillips, 1990). The Mengeidae are extinct strepsipterans and are not extant (p. 155). The Axiidae are not primitive Paleozoic homopterans but modern ditrysian lepidopterans without a fossil record; and the nematoceran fly subfamily L*i*moniinae (p. 246) is misspelled L*e*moniinae, suggesting that another group of ditrysian lepidopterans possess a fossil record they do not have. Lastly, the thysanopteran families Ceratothripidae and Pygothripidae (p. 61) are apparently not recognized as such by modern systematists (Heming, 1993).

I recommend this book for all entomologists—even those with just a passing interest in fossil insects. When compared to other book-length, biological summaries of amber deposits, Poinar's book fills a major vacuum for three reasons. First, unlike previous summaries, Poinar's book focuses on all major amber deposits, and not just Baltic amber, thus providing a spatiotemporal perspective for important amber depoists. Second, of the nine or so previous volumes on amber, almost all are in German, and only Larsson's (1978) and Poinar's volume are accessible to most English-speaking readers. Last and more importantly, unlike his predecessors, Poinar poignantly explores in his last chapter those current research areas where the study of amber is headed, including studies that go beyond the description and enumeration of taxa. These include calculation of extinction rates for insect species and genera, of which recent studies support the observation that insect taxa have exceptionally long geochronologic ranges when compared to other organisms; intriguing distributional patterns that paleobiogeographically unite amber taxa with their descendants that presently occur on separate continents or in isolated corners of the world; reconstruction of plaeoenvironments and the ecologies of ancient organisms; and, most intriguing of all, the possibility of extracting DNA as a tool for conducting phylogenetic analyses of extinct taxa, their modern descendants, and related lineages (see also Cano et al., 1992; DeSalle et al., 1992).

As exciting as these research programs are, I am still left with one unsolved mystery that was unaddressed in *Life in Amber.* Why are there no pre-Cretaceous ambers of biological importance? Although recently there has been identification of apparently araucariaceous Triassic amber (Litwin and Ash, 1991), it lacks biological inclusions and is highly fractured. Notably, the major amber-producing conifers of the families Araucariaceae, Taxodiaceae and Pinaceae all are traceable back to the Triassic Period of the early Mesozoic (Taylor and Taylor, 1992), and good araucariaceous and taxodiaceous woods with resin canals are found in sedimentary rocks from the subsequent Jurassic Period. Whether pre-Cretaceous conifers produced resin in significant volumes to be geologically widespread and noticed remains unexplored, although Litwin and Ash's report gives us cause to be optimistic for the possibility of amber-entombed, Triassic and Jurassic insects!—*Conrad C. Labandeira, Smithsonian Institution, National Museum of Natural History, Department of Paleobiology, MRC: 121, Washington, D.C. 20560.*

LITERATURE CITED

Averitt, P. 1975. Coal resources of the United States, January 1, 1974. Bull. U. S. Geol. Surv. 1412:1–131.

Cano, R.J., H. Poinar and G.O. Poinar, Jr. 1992. Isolation and partial characterization of DNA from the bee *Proplebia dominicana* (Apidae: Hymenoptera) in 25–40 million year old amber. Med. Sci. Res. 20:249–251.

Carpenter, F.M. 1992. Superclass Hexapoda. *in:* R. L. Kaesler, E. Brosius, J. Keim and J. Priesner, (eds.), Treatise on Invertebrate Paleontology, Part R (Arthropoda 4), 3:xxi + 1–655. Geological Society of America, Boulder.

Commonwealth Scientific and Industrial Research Organisation. 1991. The Insects of Australia: A Textbook for Students and Research Workers. Cornell University Press, Ithaca, N.Y. 1137 pp.

Cross, A.T. and T.L. Phillips. 1990. Coal-forming plants through time in North America. Int. J. Coal Geol. 16:1–46.

DeSalle, R., J. Gatesy, W. Wheeler and D.A. Grimaldi. 1992. DNA sequences from a fossil termite in Oligo-Miocene amber and their phylogenetic implications. Science, 257:1933–1936.

Feduccia, A. 1980. The Age of Birds. Harvard University Press, Cambridge, MA. 196 pp.

Grimaldi, D.A. and J. Maisey. 1990. Introduction. *in:* D.A. Grimaldi (ed.), Insects from the Santana Formation, Lower Cretaceous, of Brazil. Bull. Am. Mus. Nat. Hist. 195:5–14.

Heming, B.S. 1993. Structure, function, ontogeny, and evolution of feeding in thrips (Thysanoptera). *in:* C.W. Shaefer and R.A.B. Leschen (eds.), Functional Morphology of Insect Feeding, 3–41. Entomological Society of America, Lanham, MD.

Jell, P.A. and P.M. Duncan. 1986. Invertebrates, mainly insects, from the freshwater, Lower Cretaceous, Koonwarra Fossil Bed (Korumburra Group), South Gippsland, Victoria. Mem. Assoc. Australasian Paleontol. 3:111–205.

Larsson, S.G. 1978. Baltic amber—a palaeobiological study. Entomonograph 1:1–192.

Litwin, R.J. and S.R. Ash. 1991. First early Mesozoic amber in the Western Hemisphere. Geology 19:273–276.

Martins-Neto, R.G., J.C.K. Santos and M.V. Mesquita. 1991. A paleoentomofauna do nordeste Brasileiro: estado do arte. Soc. Brasil. Geol. XIV Simpósio de Geologia do Nordeste, 12:59–62.

Meyer, H. von. 1861. Vögel-Federn und Palpipes pricus von Solnhofen. Neues Jahrb. Mineral., Geol., und Paläntol. 1861:561.

Rayner, R.J. 1987. March flies from an African Cretaceous springtime. Lethaea 20:123–127.

Taylor, T.N. and E.L. Taylor. 1992. The Biology and Evolution of Fossil Plants. Prentice-Hall, Englewood Cliffs, N.J. 982 pp.

J. New York Entomol. Soc. 101(4):585–587, 1993

Reproductive Behavior of Insects. Individuals and Populations.—W. J. Bailey and J. Ridsdill-Smith (eds.). 1991. Chapman and Hall. 339 pp. $95.

It may surprise many people that students of insect behavior have few books in their discipline with which to line their shelves. I know of three that purport to cover the broad spectrum of insect behavior, and frankly, they come up somewhat short. Considering the tremendous amount of work that has been done in this field, why does this void exist? The great diversity of behavior across this taxon obviously makes it a daunting task and the scarcity of college courses offered for this speciality translates to limited sales for the effort. Thus, the literature consists largely of edited volumes with narrower foci, often the outcome of a conference symposium. *Reproductive Behaviour of Insects* falls into this category. Its eleven chapters are the work of thirteen authors, some but not all of whom were part of a symposium of the Australian Entomological Society. The obvious question to be asked is "How far does this contribution go towards helping to fill the void?" The quick answer, unfortunately, is "not far."

Reproductive behavior can be viewed as a subset of behavior, but its boundaries are difficult to define. Arguably, few behaviors could be divorced from a direct or indirect role in the ultimate context of fitness—reproductive success. So, when the editors define reproductive behavior in chapter 1 as "the finding of mates, choice of mates, selection of oviposition sites, and the factors affecting the fitness of larvae," one would be hardpressed to eliminate any of these factors. However, it seems likely that this is a convenient definition based on the contents of the contributed chapters, given that other behaviors influencing reproductive fitness are omitted (e.g., adult feeding and predator avoidance). But I won't complain too much about the selective inclusion because the leaf-feeding larvae chapter is one of the better ones.

Most accounts of insect reproductive behavior limit themselves to the more narrow focus of mating and oviposition. The literature on the behavioral ecology of insect mating systems has two volumes that stand out: *Sexual Selection and Reproductive Competition in Insects,* edited by Blum and Blum; and the highly acclaimed *The Evolution of Insect Mating Systems* by Thornhill and Alcock. *Reproductive Behaviour in Insects* falls well short of either with respect to new contributions towards evolutionary explanations of mating behavior (although Alcock and Gwynne's chapter does a very good job of summarizing the evolutionary approach to studying and understanding insect mating behavior). Therefore, it is fortunate that the majority